Sharing the bi-lateral Umbeluzi River

R. Lidén[1], D. Juizo[2]

[1] SWECO International, Sweden, email: rikard.liden@sweco.se
[2] University of Eduardo Mondlane, Maputo, Mozambique, email: juizo@hotmail.com

Abstract

This study focuses on the implementation of future bi-lateral agreements on Umbeluzi River in Swaziland and Mozambique. Soon the water resources of the river is fully utilized meaning that without water management Maputo City will experience shortage of water supply. At the same time the economic development of Swaziland is dependent on the extensive sugar cane plantations that are irrigated with water from the Umbeluzi. Water apportionment in international rivers, between agriculture and urban water supply is, however, not a simple question of trade off analysis where an economic or social function can be maximized in terms of benefit. Several factors affect the implementation of an equitable sharing principle. Prominent factors are hydrological data uncertainty, lack of adequate modeling tools, insufficient institutional capacity and poor communication between stakeholders. The main challenge for the implementation of an agreement is, however, the stakeholders' willingness to cooperate, which in turn is linked to their sense of fairness on decisions imposed by officials.

Keywords: *International rivers, Water apportionment, The Umbeluzi River.*

1 Introduction

Water shortage is a major problem in many regions of the world and is identified as one of the potential reasons for future international conflicts. The management and sovereignty of international watercourses has been under discussion for decades exemplified by the adoption of the Helsinki rules already in1966. Integrated water resources management is today well known to all water resources engineers and its ideas slowly make a way into the offices of the policy makers. A framework for integrated management of international watercourses was established in the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses and today a large number of water-sharing agreements exists worldwide (cf. Green Cross International 2000). Regional frameworks have further been developed to take into account the specific situations in different parts of the world, e.g. the SADC Protocol on Shared Watercources (1995) for Southern Africa.

Mozambique is one of the countries that have adopted the procedure suggested by the 1997 Un Convention and the 1995 SADC Protocol. Through its location by the Indian Ocean Mozambique is the most downstream country for nine major rivers in southern Africa. Mozambique is thereby immensely dependent on the upstream countries' water use to secure its own water supply. Joint Water Basin Commissions have been established for the major rivers in Mozambique and a water-sharing agreement on the Incomati and Maputo rivers in southern Mozambique has been recently signed between South Africa, Swaziland and Mozambique. The "Tripartite Interim Agreement for the Co-operation in the Protection and Sustainable Utilization of the Water Resources of the Incomati and Maputo Watercourses" was signed in 2002 after many years of negotiations (Carmo Vaz and van der Zaag 2002). On a time perspective until 2010 it specifies the water use allocation as annual averages for each of the three countries for first priority supplies (i.e. domestic, livestock, industry and ecological water requirements), irrigation and afforestation. It further targets water requirements for the ecosystems of the watercourses as minimum flows for specific points in the rivers.

Recently a water resources assessment of the Umbeluzi River basin, which is located between the Inkomati and Maputo rivers, has been conducted aiming to prepare the basis for negotiations between Swaziland and Mozambique for a water-sharing agreement. The Umbeluzi River is today the only water supply for the City of Mozambique. At the same time Swaziland utilizes the Umbeluzi River for large-scale sugar cane production that are vital for the country's economy. The diplomatic relations between Swaziland and Mozambique are good and there is a common determination to reach an agreement between the countries regarding the use of Umbeluzi River. Because both countries are parties of the tripartite Incomati-Maputo agreement it is likely that the structure of the new agreement will follow this existing one for the neighboring rivers.

In connection with the coming negotiations for the shared use of the Umbeluzi water, issues can, however, be raised regarding the soundness and applicability of an agreement such as the Incomati-Maputo agreement:

- Firstly, the basis for the water resources assessment must be questioned. The methods developed to quantify the available water resources all base their data on observed river runoff records that are assumed to be accurate. That this is not the fact has been exemplified in the Umbeluzi River through two recent studies (JTK & Associates 2003, SWECO & Associates 2003) that have independently studied the water resources in the two countries. The two studies arrive at a different border flow mainly because they have used different runoff records as the basis for the hydrological models.
- Secondly, the inflexibility of the system analysis models used to optimize the available water resources must be questioned (cf. Chapman et al 1995). The models currently used in southern Africa do not take into account social and economic benefits and when the important parameters for how water is prioritized are set there is little or no stakeholder participation.
- Thirdly, and maybe most important, the foundation for operational management of the international rivers according to the agreement is non-existent. The present water use of the countries in southern Africa is the results of a long history with different governance regarding water rights. It is also a mixture of large-scale water utilization, e.g. from large dams and small-scale farming pumping water directly from the rivers. The possibility to regulate such a system in an extreme situation such as a severe drought period is almost impossible. It does not just require enormously advanced communication and warning systems but can also be challenged legally since many users were granted water rights long before integrated water management was on the agenda. This problem was harshly highlighted recently when the observed flows in Incomati at the border to Mozambique in September 2003, only one year after the signing of the tripartite agreement, was less than a 20% of the targeted ecological flow in the Incomati-Maputo agreement (personal communication, DNA, Mozambique).

This paper aims to review the problems associated with a future water-sharing agreement for the Umbeluzi River basin. The Umbeluzi River is in many ways an excellent example to test the applicability of integrated water resources management of international rivers. Only two countries, Mozambique and Swaziland, essentially share the river. Two main water uses, irrigation water for the main national industry and fresh water supply for the urban metropolis of Maputo City with close to two million inhabitants, stand against each other. Both countries are developing with large plans for future expansion in the industrial and agricultural areas but at the same time having enormous constraints in economy and human capacity in the governmental bodies dealing with water resources. Finally both countries have the will to share the water resources of the Umbeluzi River and are presently investing in water resources assessments to get the basis for an agreement. The main purpose of this paper is therefore to identify the challenges to achieve a feasible agreement for the Umbeluzi River that will work not only in theory but also in practice.

2 The Umbeluzi River Basin

The headwater of the Umbeluzi River is located in Swaziland close to its western border with South Africa (Figure 1). The river flows principally in an easterly direction and discharges into the Indian Ocean via the Espirito Santos estuary south of City of Maputo in Mozambique. The total catchment area of the Umbeluzi River basin is 5400 km^2 (SWECO & Associates, 2005). 40% of the area is in Mozambique, 58% in Swaziland and only 2% in South Africa. Two major tributaries join the main river, the White Umbeluzi in Swaziland and the Movene in Mozambique. Still, in Mozambique, there are two small tributaries - the Impaputo and Calichane.

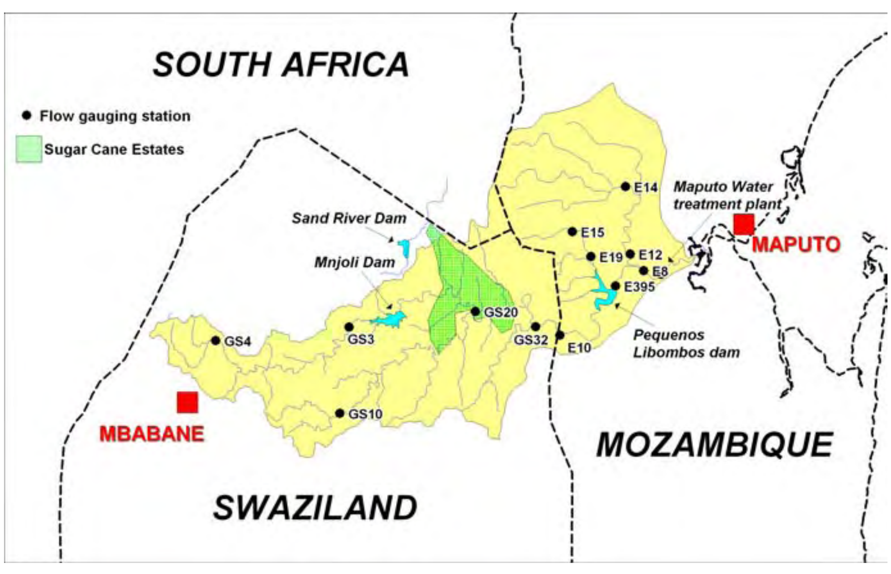

Figure 1. The Umbeluzi River basin.

The altitude increases from the sea level to almost 2000 m.a.sl. in the western part. The climate is according to Köppen classification system tropical wet and dry (Aw) in the western highlands and semi-arid (Bs) in the Middle and Lowveld. Rainfall varies from 500 mm/year in the lower parts to 1500 mm/year in the mountainous part. The basin experiences two distinct seasons; the rainy season from November to April and the dry season between May and October.

Two major dams are located in the basin. The Mnjoli Dam, with total capacity of 152 million m^3 built in 1978 with purpose to secure water for the sugar cane estates in eastern Swaziland. The Pequenos Libombos Dam in Mozambique, with total capacity of 385 million m^3, was constructed in 1987 mainly to secure the urban water supply for the City of Maputo. The intake and water treatment plant for Maputo is located some kilometers downstream of the Pequenos Libombos and the dam is therefore constantly releasing a minimum flow to allow for water supply. In addition, a small dam in the upper basin in Swaziland, the Hawane Dam (2.75 million m^3), supplies the capital Mbabane with fresh water.

Table 1. Water demand in Mozambique and Swaziland. Source: SWECO & Associates (2005).

	SWAZILAND		MOZAMBIQUE	
	Present	**2025**	**Present**	**2025**
Irrigation	229	292	17	39
Urban	12	20	76	184
Other	12	21	4	29
Total	253	334	97	252

The largest water user in the Umbeluzi River basin is irrigation (Table 1). The sugar cane estates in eastern Swaziland stand for more than 65% of the present water demand. The total estimated present water demand for surface water is 350 million m^3/year but is forecasted to increase to 505 million m^3/year by the year 2025. The available water, under natural conditions, is estimated to be 535 million m^3/year (SWECO & Associates, 2005). The climatic variability in southern Africa is, however, large, coefficient of variation (CV) for annual runoff is calculated at 0.54, and at present existing dams cannot capture all water. Thus, the 2025 water demand scenario will cause severe water shortages for the City of Maputo. This was also confirmed by SWECO and Associates (2005), which estimated the safe yield of the Umbeluzi River system. The results showed that already in approximately 2007 the City of Maputo would experience shortage of fresh water supply (Figure 2).

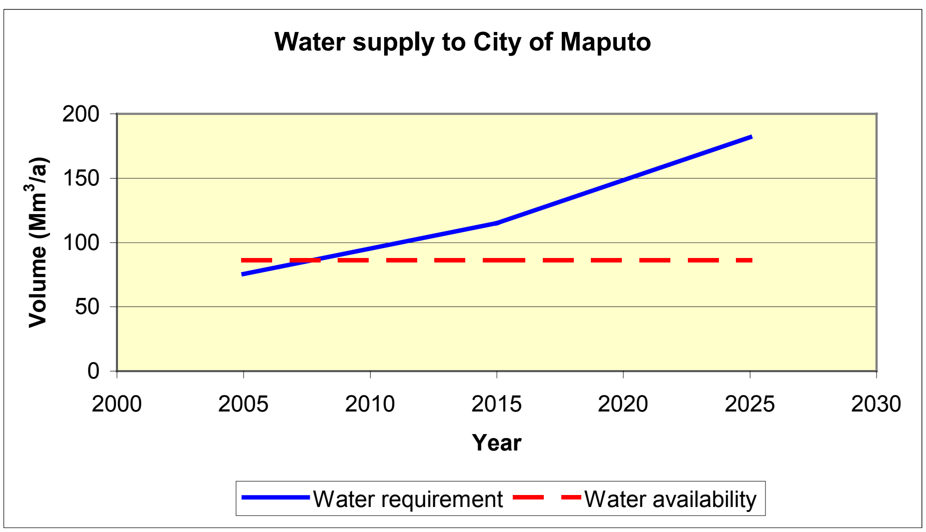

Figure 2. Projected water requirements compared with the calculated safe yield for the City of Maputo. Source: SWECO & Associates (2005).

3 Review of conditions for a future agreement on sharing the Umbeluzi River

A very important prerequisite for an agreement on bi-national water-sharing is a willingness to agree on issues at stake and allocation procedure that is accepted by both countries. Different water allocation models have been developed over the years and some of those have been applied to the SADC transboundary river basins (cf. Hoekstra et al., 2001; Giordano and Wolf, 2002; van der Zaag and Savenije, 2000, van der Zaag et al., 2002, Howitt, 1994, Wolf and Murakami, 1995). Some models are based on the concept that water is an economic good. Therefore, it follows market laws and the benefit from its use should be maximized on economic conditions. Other models try to apply the concept of equity in sharing, mostly applying the proportionality concept together with the historical use of the water resources.

The case of Umbeluzi does not seem to adapt easily to a single model of those above described. Hence, the Governments of both countries have chosen to cooperate in matters related to water resources apportionment. This will be based on the most up-to-date concepts substantiated in the international law and the SADC Revised protocol. As a first step, a Joint Basin Commission was established and recently, a Joint Umbeluzi River Basin Study (JURBS) was implemented. JURBS aimed to evaluate the river basin condition and outline a development scenario that will maximize the benefits of water resources utilization while still encapsulating the concept of equity in sharing and sustainable development, without compromising the interests of future generations. Hence, the agreement in water apportionment for Umbeluzi will likely follow the common procedure: 1) Water resources assessment, 2) System analysis to evaluate different scenarios, 3) Water allocation to different countries and users to be part of the agreement, and 4) Implementation and monitoring of the agreement by the established joint institutional set up. Below a review of the major parts of this procedure is made for the Umbeluzi case.

3.1 Hydrological Data

The flow gauging network in Umbeluzi is fairly dense (Figure 1). In total there exist 12 stations that have monitored historical runoff. All stations in Swaziland and the E10 station in Mozambique close to the border consist of weir structures, either sharp-crested weirs or cramp weirs. The others are natural controls.

A closer look at observed data reveals that there are a lot of uncertainties involved (SWECO & Associates, 2005). Many stations have very short records or have obviously erroneous ratings since the structures have not been maintained. The 1984 and 2000 cyclones hitting the area caused large floods that severely damaged the runoff stations. Further, many uncertainties exist with the rating for flows when the built structures are flooded. The two most reliable stations close to the border between Swaziland and Mozambique, GS20 and E10, exemplify this by showing preposterous results (Table 2 and Figure 3).

Table 2. Comparison of observed runoff at GS20 and E10 for the period 1973-79.

	GS20	E10
MAR (Mm^3/yr)	527	481
Catchment area (km^2)	2,429	2,986
Areal runoff (mm/year)	217	161

Table 2 shows that GS20 gives in average more runoff than the downstream E10, with no physical explanation since no large water abstraction is located between the stations. Figure 3, confirms the discrepancies and shows that the difference is mainly for the flood periods, i.e. a periods when the structures are submerged. Thus, a conclusion is likely to be made that at least one of the stations has poor ratings for medium to high flows.

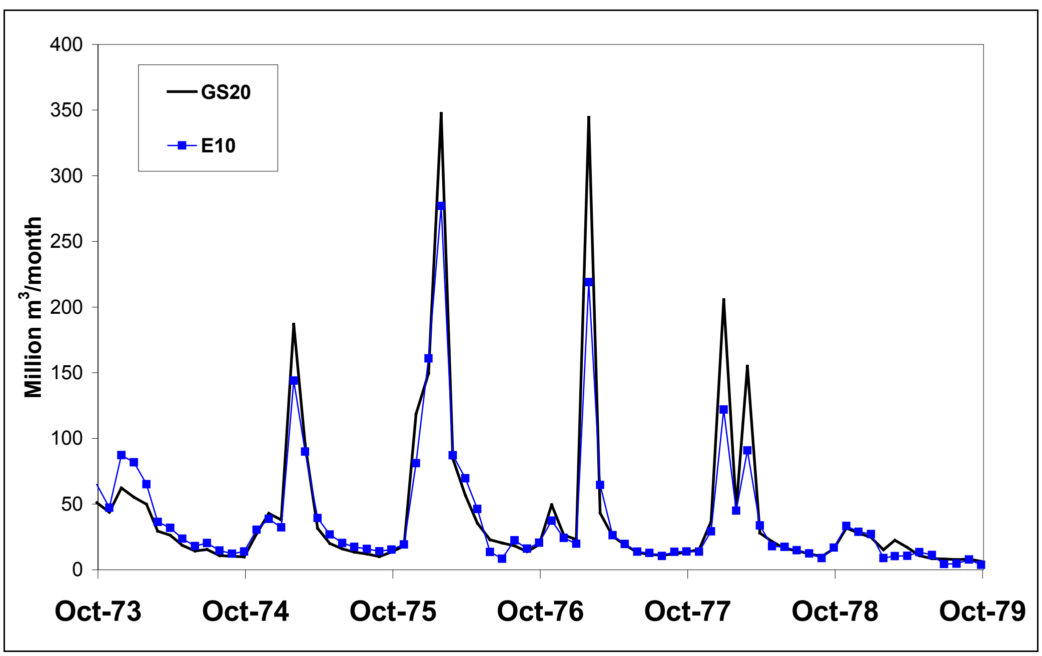

Figure 3. Observed runoff at GS20 upstream of the border in Swaziland and E10 downstream the border in Mozambique.

As a result of the uncertainty in observed runoff data, significant differences exist with regards to the assessment of the available water resources in the two previous studies conducted by JTK & Associates (2003) and SWECO & Associates (2003). The calculated difference in the estimated average natural flow at the border between the two countries was in the order of 200 million m^3/year. This figure is three times the current water consumption of the City of Maputo. Both studies used the same methodologies and tools, and the level of detail was similar. For example, the Pitman hydrological model (WRMS2000), widely used in southern Africa, showed results well within the acceptable range in both studies. As a conclusion, both studies were considered as objectively conducted and at high professional standards, leaving the reason for the different results to the different used input data. The JTK consultants based their study on the GS20 station in Swaziland, while the SWECO study has relied on the E10 in Mozambique. However, the input data could all be judged to be within a range of accuracy that can reasonably be defined on the basis of the quality of observed data. Accordingly, the input data chosen and the calculated available water resources in both studies could therefore be regarded as adequate. However, the impact of considering either figure in the agreements is substantial, particularly if one considers the intention of both countries to expand in their water needs.

A thorough review of the flow gauging stations and a quality analysis of the historical runoff data was made by SWECO & Associates (2005), which conducted a joint study for both countries sharing the Umbeluzi River. The study led to an updated hydrological model giving one final estimate of available natural water. However, the uncertainty in the historical data remains and compromises were needed to choose the final model parameters. The results were therefore accompanied with a strong recommendation on rehabilitation of the flow gauging network and improved future monitoring and confirmation of the water resources of the Umbeluzi River.

3.2 System Analysis

System Dynamics Theory has been gaining wide support as the future platform under which water resources planning will take place. One major advantage of System Dynamics is its feedback loops that allow the system to adjust its functioning mechanisms in order to achieve a new operation optimum. System analysis models are implemented by water resources experts with the main objective being to maximize the benefit of using water resources taking into account environmental conservation, social satisfaction and economical benefit.

The river basin system analysis is largely based on catchment hydrology of the area. The human influence in the process is normally obtained through informative discussions oriented by system experts. The regional, political and economical development strategies are considered within the development scenarios. Often, depending on the resulting consequence to the system sustainability, the Governments can be requested to make changes on them. An important aspect is the fact that system experts who have their own view of sustainability in natural resources, derived from their experience with the subject and background as well as their political beliefs, largely control the model itself. Stakeholders' role in the performance of the system is not a direct factor or input in the model; their views are captured through the political strategies or during limited interactions with the system expert in model development phase.

A sensitivity analysis made in connection with the system analysis conducted by SWECO & Associates (2005) shows that small changes in the WRYM model's penalty system can change the result significantly. By changing the penalties such that the Mnjoli and Pequenos Libombos reservoirs (see Figure 1) are operated jointly to maximize the water supply to the City of Maputo, the safe yield for the urban supply was increased with almost 30% (Figure 4).

Figure 4. Results of a sensitivity analysis of safe yield for the City of Maputo using the WRYM system analysis model.

A prioritization of water for urban consumption is commonly found in international water policies and also in the water acts of both Swaziland and Mozambique. However, the Mnjoli Dam was constructed by and for the sugar cane industry in Swaziland and is presently thus used primarily for irrigation. Consequently, by their aim to describe the current system, the system analysis set up by SWECO and Associates (2005) assumed the latter. Whether the Mnjoli should support downstream users in Mozambique or not is an issue for negations between the countries. The example above, however, illustrates the power of the system analysis expert to influence the fundamental basics for water allocation by different penalty systems that are normally incomprehensible for the policy makers negotiating the water allocation.

A general review of the system analysis tools such as the WRYM model that was used in the Umbeluzi case also shows that in the process of simplification of the reality there are aspects neglected in the modeling of the system. One of the most important is the human nature of breaking the rules. For example in a drought situation the model is set to perform adjustment in water demand restricting the off takes to irrigation first, thereafter lowering the water consumption for water supply and lastly to the environmental flow requirements. Similarly, there are operational rules for dams that change according to the hydrological situation. However, in reality, due to human errors or even intentional acts often these rules are broken. In this aspect, the schematic system analysis for Umbeluzi shows uncertainties in respect to the true representation of the system, operation and behavior. The existence of a number of small-scale farms with complicated operational procedure and with unstable financial situation that make them operate in quite erratic way creates a problem in modeling.

It is also found that system analysis tools use historical data to perform their simulations. Hence, the resulting “best scenario” in river basin utilization fails to represent the most extreme situation e.g. severe droughts in the case of Southern Africa are the most critical period. Recent simulation models use the probabilistic theory as part of their simulation procedure (Basson et al., 1996) where a set of synthetic time series is generated to form the basis for simulation. In this way, the development options are chosen such that the resulting simulation will have the least failure in the system. Depending on how representative the data is, one may still be able to capture the full variability of the event to include the low extreme values, which in turn will determine the robustness of the development option.

3.3 Institutional Capacity

Implementation of a bi-national water-sharing agreement requires that the involved sovereign states have institutions capable of implementing and monitor the agreement. Institutional capacity is the ability of organizations as a whole to carry out their duties, functions and responsibilities and is not limited to have staff with the technical skills. Institutional capacity therefore includes organisational, managerial, economical and technical capability. It should also be emphasised that capacity building is an on-going process of strengthening and making available the ability of each and every member of staff as well as the organisation as a whole (Lamoree and Harlin, 2005).

In Mozambique, the existing institutional set-up is more or less adequate for implementation of any future agreement in Umbeluzi. The water management board ARA-Sul has some ten years experience in water resources operations and within its structure there is already the Umbeluzi River Basin Management Unit (UGBU) responsible for day to day operation of Pequenos Libombos dam, hydrometric network, water quality monitoring, liaison with stakeholders etc. In Swaziland the water law framework is still reforming in consequence of the new Water Act introduced in late 2003. A set of institutions is yet to be created and capacitated to discharge the envisaged powers.

Both countries, however, have serious limitations in terms of economic resources and qualified human resources, which are key elements in implementation and enforcements of an agreement. The recent study by SWECO and Associates (2005) highlights three important capacity areas to be improved for the implementation of a water-sharing agreement:

1. Hydrological and system analysis modeling for water allocation – The agreed future water allocation will most likely be in between, or variant of, the pre-calculated scenarios for future water use in the Umbeluzi River basin. New information may also be available in the future that may change the prerequisite for the water balance analysis. It is therefore essential that the coming process of water allocation in the Umbeluzi River basin be made in parallel with updated detailed water balance analysis. Furthermore, to fully understand and make conclusions of the result from the water balance analysis models these should be operated by the negotiating parties themselves, i.e. by the water authorities of Mozambique and Swaziland.
2. Monitoring of river flow and water quality for enforcement of a future agreement – The access to continuous data is necessary for planning of water distribution and efficient water use. It is necessary for enforcing the agreed water allocation by controlling water outtakes, releases, pollution loads, etc. Monitoring does also involve the process of data management, storage and quality control. Even if a rudimentary network is currently in place the level of accuracy and detail is not sufficient. The present gauging infrastructure and monitoring procedures must therefore be improved in both countries.
3. Stakeholder participation - A large part of the agreement, e.g. water allocation, relies on the willingness of the stakeholders to comply. It is essential to involve the stakeholders already in the process of establishing a joint river basin management agreement. An identification and mobilization of stakeholders followed by an assessment of how stakeholders quantitatively and qualitatively depend on the Umbeluzi River is needed in both countries. In consequence the capacity to conduct and drive this interaction with the stakeholders needs to be raised.

The IncoMaputo agreement highlighted the current human resources and institutional inability, within the three countries, to cope with the objectives set forth. Article 14 of the same urges the countries to, individually and, where appropriated, jointly, take actions to ensure capacity building development to implement the agreement.

3.4 Stakeholder Participation and Communication

An important aspect in perceiving fairness in water allocation is the stakeholder perception of their involvement in the allocation process accounting to both self-interest and tempered with pro-social motivations (Syme et al., 1999). The penalty system used in the system analysis tools to adjust the water allocation in the Umbeluzi is based on the hydrological situation in the river basin. However, the reality is that this knowledge is not general but piecewise stored in different authorities. There is hardly any communication to the stakeholders, especially the small-scale farmers, about the hydrological status of the system and this impedes them from acting on the right time if water restrictions apply. The existing set-up indicates that whereas the model has prior knowledge of shortage of water at the beginning of a given time step simulation, the reality is that only after a certain time, at least a month, different stakeholders can evaluate the experienced water distribution compared to fairness in allocation of water. This implies that in real operation the question at stake becomes not how to distribute limited resources but how to compensate the users that did not receive their fair share of resources in the given time step.

Figure 5 shows the schematic representation of the communication flow system in Umbeluzi River basin. The communication is ironically between the headwaters and the river mouth (Water authorities in Mbabane and ARA Sul in Maputo). There is hardly any direct communication along the hydrometric station network or river channels. It is often the case that the Mnjoli Dam is operated without taking into account the situation in Mozambique. In the event of a critical situation at Pequenos Libombos Dam, the operator needs to provide ARA Sul with information to file a complaint to the Mbabane authorities which, based on the agreement, if existent, would prompt the Mnjoli Dam operator to take actions to correct the situation. Another problem with the current set up is that the operator at Mnjoli Dam has little knowledge of the real off takes after releasing water because the hydrometric information collected on the downstream stations is only sent to the water authorities in Mbabane.

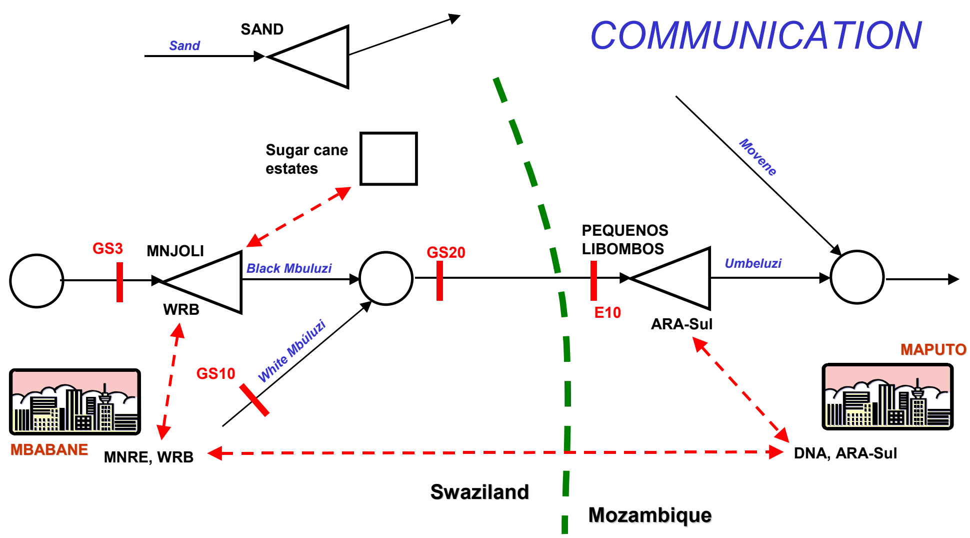

Figure 5. Principle sketch of the communication routes regarding hydrological information in the Umbeluzi River basin.

Water institutions responsible for water management can only provide information to be used in water apportionment especially, concerning the dam releases and river off takes by users. This last component and most important is the most difficult to attain since it relies on users' willingness to comply. In the end, it is the willingness of the stakeholders that can guarantee the fair distribution of water resources in a river basin. In Umbeluzi there are many independent irrigation schemes with their own off taking system that leaves the water management dependent on their discretion. The other issue in real-time water apportionment is real-time communication with a large number of smallholder irrigation schemes. Passing on the message is difficult. Also, there is the lack of experience in information dissemination, which seems to work only during flood events. The language problems along the river basin are also a challenge to real-time water allocation.

4 Conclusions

Using the example of Umbeluzi River basin this review has shown that while an agreement on water sharing can be achieved within reasonable period, the implementation of the agreement giving an equal and fair water allocation in real-time is far from reality. Four prominent factors that effects the possibility to implement an equitable and functioning agreement are 1) hydrological data uncertainty, 2) lack of adequate system analysis tools and procedures, 3) insufficient institutional capacity among the water authorities, and 4) poor communication between stakeholders and water authorities.

The main challenges remain to the actual implementation of a water-sharing agreement when subjected to different stress situations. The agreement is often of good quality and based on sound analysis of the performance of the system. Nonetheless, during low flow conditions, upstream stakeholders have no tools at hand to decide on the fair amount of water to leave in the river to the downstream users. It is often the case that downstream users are the first to experience extreme droughts yet the upstream justification is that the system fails to deliver more water. In general, the extent and intensity of an experienced drought is more severe than what the model would simulate.

Stakeholders are the cornerstones of the success of any agreement since they are the actual water abstractors and their willingness to cooperate with measures adopted by the river basin management is very critical. Procedures for system analysis must be developed where stakeholders can take a more active part. Otherwise there is large likelihood that the implementation of the findings from the models fails. The stakeholders' willingness to cooperate is further linked to their sense of fairness on decisions imposed by officials. Communication both during the development and implementation of the water-sharing agreement is therefore fundamental. Whatever procedure is adopted for Mozambique and Swaziland, the challenge will further remain on the institutional capacity and the need to adapt the legislative framework to cope with these issues. This need is evident when looking at the IncoMaputo agreement where the issues of Capacity Building are clearly marked.

References

Basson, M.S, Allen, R.B., Pegram, G.G.S and van Rooyen, J.A (1996): Probabilistic Management of Water Resources and Hydropower Systems; Water Resources Publications, LLC, 434 pp, ISBN 918334-89-6, USA and Canada.

Carmo Vaz, A. & van der Zaag, P., (2003): Sharing the Incomati waters: Competition in the balance, Water Policy 5, No 4, pp 349-368.

Chapman, R.A. ; Manders, P.T. ; Scholes, R.J. ; Bosch, J.M (1995) : Who should get the water? Decision support for water resource management, Water Science and Technology, vol 32, issues 5-6, pp 37-43, Pergamon, Elsevier.

Giordano, M. A. & Wolf. A. T., (2002): Incorporating Equity Into international Water Agreements, Social Justice Research, Vol. 14, No. 4, 346-366, Plenum Publishing Corporation

Green Cross International, (2000): National Sovereignty and International Watercourses, Green Cross.

Hoekstra, A.Y. ; Savenije, H.H.G. ; Chapagain, A.K., (2001): An Integrated Approach Towards Assessing the Value of Water: A Case Study on the Zambezi Basin, Integrated Assessment, vol. 2, issue 4, pp 199-208, Kluwer.

Howitt, R. E. (1994): Empirical analysis of water markets institutions: The 1991 California water market, Resources and Energy Economics 16(1994)-pp. 357-371, Elsevier.

JTK Associates (2003) Assessment of water availability in the Komati and Mbuluzi, Consultancy report to the Government of Swaziland, Water Resources Branch.

Lamoree, G., Harlin, J. (2002): Institutional Capacity Building within the Water resources Sector of developing Countries, Part 1: A Framework for Analysis, Water International, Vol. 27, No 4, pp. 542-549.

SWECO in association with Consultec, Impacto and BKS ACRES (2003): National Water Resources Development Plans for Maputo, Umbeluzi and Inkomati River Basins, Consultancy report to the Government of Mozambique.

SWECO in association with Consultec, Impacto, Knight Piesold and BKS ACRES (2005): Joint Umbeluzi River Basin Study, Consultancy report to the Governments of Mozambique and Swaziland.

Syme, G.J. ; Nancarrow, B.E. ; McCreddin, J.A. (1999): Defining the components of fairness in the allocation of water to environmental and human uses, Journal of Environmental Management , Vol. 57, issue 1, pp 51-70, Academic Press , Academic Press.

van der Zaag, P. ; Savenije, H.H.G., (2000): Towards improved management of shared river basins: lessons from the Maseru Conference, Water Policy, vol. 2, issue 1-2, pp 47-63, Elsevier, Elsevier.

van der Zaag, P. ; Seyam, I.M. ; Savenije, H.H.G., (2002): Towards measurable criteria for the equitable sharing of international water resources, Water Policy, Physics and Chemistry of the Earth, Parts A/B/C, vol. 27, issue 11-22, pp 805-813, Pergamon, Elsevier.

Wolf, A.T. & Murakami, M. (1995): Techno-political Decision Making for Water Resources Development: The Jordan River Watershed, Water Resources Development, vol. 11, No2, Journals of Oxford Ltd.